PB-217 391

WATER RESOURCES STUDY, SOUTHEASTERN OKLAHOMA AND SOUTHWESTERN ARKANSAS. STUDY OF POTENTIAL NEEDS AND VALUE OF WATER FOR MUNICIPAL, INDUSTRIAL, AND QUALITY CONTROL PURPOSES

Public Health Service
Dallas, Texas

July 1962

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WATER RESOURCES STUDY

SOUTHEASTERN OKLAHOMA AND SOUTHWESTERN ARKANSAS

Study of Potential Needs and Value of Water for Municipal, Industrial, and Quality Control Purposes

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

In Cooperation with the

DEPARTMENT OF THE ARMY
U. S. Army Engineer District - Tulsa, Oklahoma

JULY 1962

33

WATER RESOURCES STUDY

SOUTHEASTERN OKLAHOMA AND SOUTHWESTERN ARKANSAS

Study of Potential Needs and Value of Water for Municipal, Industrial, and Quality Control Purposes

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

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JULY 1962

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ACKNOWLEDGMENTS

The assistance and cooperation of agencies and individuals who aided in the assembly of data for this report are gratefully acknowledged. Special thanks are extended to the city officials, members of the Chambers of Commerce, and interested citizens in Oklahoma, Texas, Arkansas, and Louisiana who supplied data on their communities and their projected water requirements; to the Water Resources Boards in the four states for information on resources in their portions of the study area; to the public utility companies in the study area who were exceedingly cooperative in providing data concerning their operations; and to all others who assisted in this study.

SUMMARY AND CONCLUSIONS

This report presents the results of a study of the need for water for municipal, industrial, and quality control purposes, which could be supplied from 11 reservoirs located in southeastern Oklahoma and southwestern Arkansas. The reservoirs under investigation are Pine Creek, Lukfata, Broken Bow, DeQueen, Dierks, Gillham, and Millwood in the Little River basin system; Boswell on Boggy Creek; and Hugo, Clayton, and Tuskahoma in the Kiamichi River basin system. The locations of the proposed reservoirs are shown in Figure 1.

Millwood and Broken Bow are already under construction. These reservoirs were considered to be firmly committed sources of water for use in meeting the projected needs of the study area.

The following are concluded:

1. Population of the study area to be served by municipal water systems is expected to reach 2,759,000 by the year 2020. Total projected municipal water needed to serve that population is 516 mgd by 2020.

2. Industrial water requirements will increase principally as a result of the requirements for pulp and paper production, petroleum refining, and other industrial activities expected to locate in the study area. Total industrial water needed for the year 2020 is estimated to be 900 mgd.

3. By the year 2020, 950 mgd will be needed from storage for streamflow regulation to maintain a desirable quality of water in the streams of the study area (excluding the Red River) into which adequately treated municipal and industrial wastes are discharged.

4. Projected net water requirements (excluding existing sources of supply) by the year 2020 are 1,703 mgd.

5. The full yield from storage of the reservoirs proposed for Boggy Creek and the Kiamichi River can be used at this time to provide some improvement in the quality of the Red River below Lake Texoma until the natural and manmade salt pollution in the upper Red River basin is brought under control. After that, water released from storage in the reservoirs located on Boggy Creek

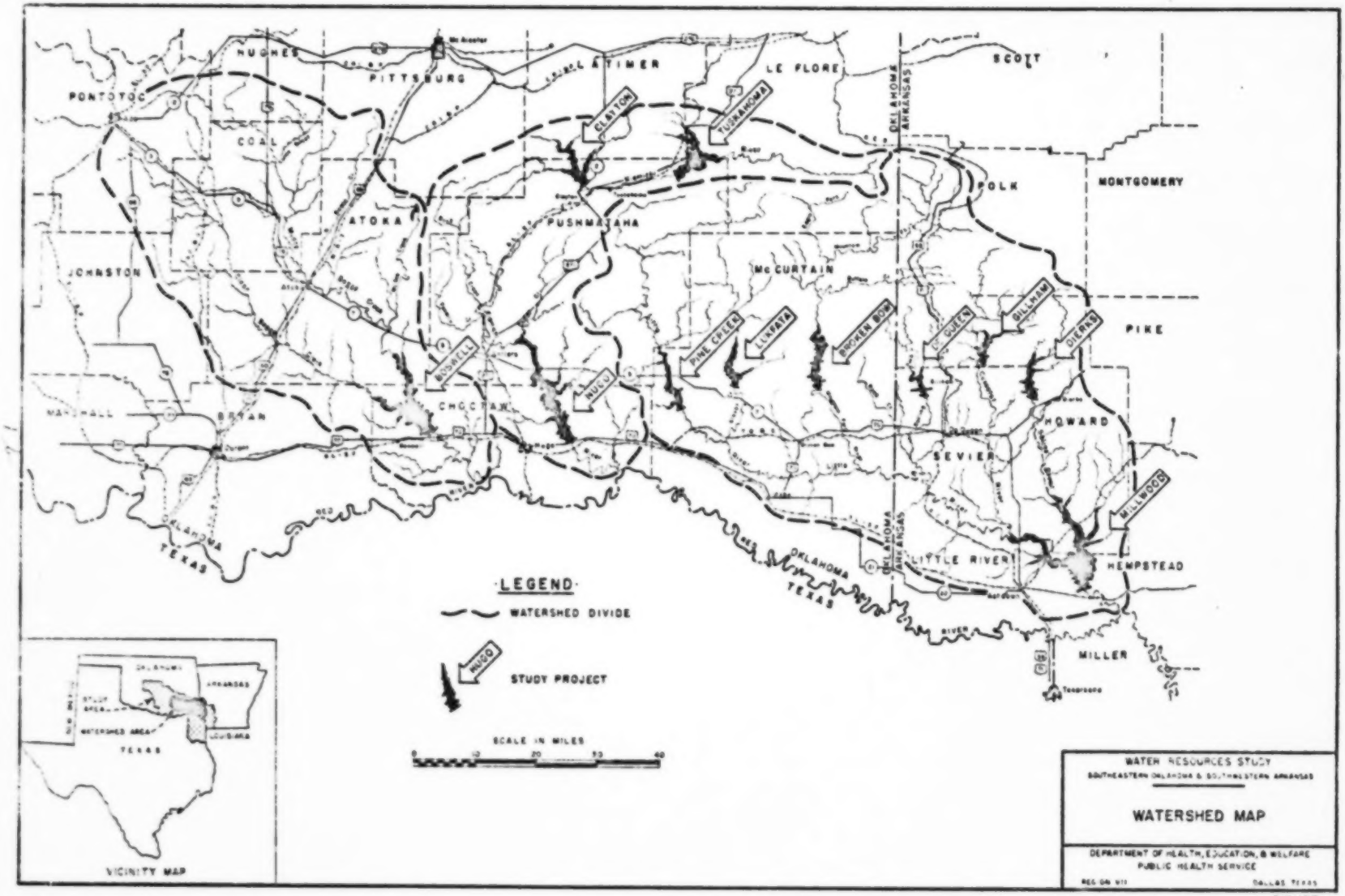

NUGHES
PONTOTOC
PITTSBURG
COAL
LATIMER
LE FLORE
SCOTT
CLAYTON
TUSKAHOMA
OKLAHOMA
ARKANSAS
ATOKA
PUSHMATAHA
POLK
MONTGOMERY
JOHNSTON
McCURTAIN
BOGGY CELL
NUKO
PINE CREEK
LUKFATA
BROKEN BOW
J. CREEK
GILLHAM
DIERKS
PIKE
MARSHALL
BRYAN
CHOCTAW
HOWARD
SEVIER
MILLWOOD
OKLAHOMA
TEXAS
LITTLE RIVER
HEMPSTEAD
MILLER
LEGEND
WATERSHED DIVIDE
STUDY PROJECT
SCALE IN MILES
0 10 20 30 40
VICINITY MAP
WATER RESOURCES STUDY
SOUTHEASTERN OKLAHOMA & SOUTHWESTERN ARKANSAS
WATERSHED MAP
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII
DALLAS, TEXAS

FIGURE 1

and the Kiamichi River can be used to further improve the quality of the Red River and/or to supply the increasing needs created by projected growth in the study area.

6. Total annual benefit of storage for municipal, industrial, and quality control waters in the proposed projects is $2,906,500. The benefits claimed for each of the reservoirs and the distribution between municipal and industrial water supply and water quality control supply are summarized in Table 8, page 16.

AUTHORITY AND REQUEST

Title III, Public Law 85-500, authorizes the inclusion of storage for present or anticipated future demand or need for municipal or industrial water in any reservoir project surveyed, planned, or constructed by the U. S. Army Corps of Engineers. A Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare states that the Corps of Engineers will consult with the Public Health Service to obtain the views and recommendations of this agency on present and prospective needs for such water supply and the desirability of meeting those needs from the project or projects under consideration, and that the Public Health Service will prepare and submit a report to the Corps of Engineers setting forth its findings and recommendations on each individual survey or review investigation involving improvements which may be useful and justified in developing water supplies.

This study was initiated in accordance with the foregoing agreement and in response to a letter of request, dated September 25, 1959, from the Tulsa District, U. S. Army Corps of Engineers.

Before completion of the study and submission of the Public Health Service report to the Corps of Engineers, the Federal Water Pollution Control Act, Public Law 84-660, was amended by Public Law 87-88. This law (as amended) requires that any Federal agency planning a reservoir shall give consideration to inclusion of storage for streamflow regulation for the purpose of water quality control, and that the need for and value of such storage shall be determined with the advice of the Secretary of Health, Education, and Welfare. This new requirement necessitated restudy of the proposed projects.

AVAILABILITY AND SUITABILITY OF WATER FROM THE PROJECT FOR MUNICIPAL AND INDUSTRIAL USES

Quantity Available

Table 1 presents pertinent data on storage capacity, yield, and related facts regarding the proposed projects. The reservoirs under consideration can provide 1,906 million gallons per day of water for municipal, industrial, and water quality control uses.

Water Quality

The several watersheds where the reservoirs will be located are not presently subjected to extensive contamination of wastes from communities, industries, or other sources. The only exception to the good chemical quality of water from the watersheds is the iron content of the Kiamichi River. Iron in the amount anticipated is not difficult or costly to remove.

These waters are acceptable as a raw water supply for general municipal and industrial purposes.

Table 1

Pertinent Data - Study Projects

Project	Location		Drainage Area (sq.mi.)	Water Supply Pool Storage (ac-ft)	Water Supply Pool Yield (mgd)
	Stream	At Mile			
Boswell	Boggy Cr.	18.9	2,273	1,246,200	555
		Kiamichi Basin System			
Hugo (initial)	Kiamichi R.	17.6	1,709	20,000	35
Tuskahoma	Kiamichi R.	118.5	347	231,000	200
Clayton	Jackfork Cr. (Kiamichi)	2.8 (103.5)	275	183,000	140
Hugo (with Clayton operating)				95,200	140
Hugo and Clayton Total				278,200	280
Hugo (with Clayton & Tuskahoma operating)				229,000	280
Hugo, Clayton, and Tuskahoma Total				643,000	620
		Little River Basin System			
Pine Creek	Little R.	145.3	635	70,000	120
Lukfata	Glover Cr.	16.8	291	31,000	60
DeQueen	Rolling Fork Cr.	22.8	169	18,000	32
Gillham	Cossatot R.	49.0	271	29,200	60
Dierks	Saline R.	57.0	113	12,100	19
Broken Bow	Mountain Fork Cr.	20.3	754	80,600	175
Millwood	Little R.	16.0	4,144	150,000	265

Note: Total yield is 1,906 mgd, sum of yields in lines 1, 8, and 9 through 15.

DELINEATION OF STUDY AREA

Climatic conditions and probable distribution of industry and population were taken into consideration in establishing the boundaries. There is a large difference between average annual rainfall of the western portion of Oklahoma and that of the eastern part of the State. Annual precipitation is approximately 20 inches in the west compared with 46 inches in the east. The Arkansas and Red Rivers which might be used to supply the needs of the western and central portions of Oklahoma are polluted with salts to such an extent that their waters are unsuitable for most domestic and industrial uses.

Those counties which might reasonably be served directly from the proposed projects and those adjoining counties which would either be markedly affected by the projects or are an economic part of the potential water service area were included in the study area. This area is shown on Figure 2.

The Oklahoma City metropolitan area is, and will probably continue to be, the largest population center in this study area. It is located at an average distance of 150 miles from the proposed reservoirs and has exhibited a growth pattern which indicates a very substantial need for additional water in the future.

The areas immediately adjacent to the reservoirs and the intervening area between the reservoirs and Oklahoma City could be served by facilities used to transport water from the reservoirs to the Oklahoma City metropolitan area. The availability of good quality water and the construction of the proposed reservoirs could also influence the economy of the nearby area which lies in southeastern Oklahoma, southwestern Arkansas, and northeastern Texas. The potential needs of these several areas were therefore also considered.

DETERMINATION OF WATER NEEDS

The determination of the future water needs of the study area was based on detailed economic and population projections, coupled with analyses of projected per capita and industrial water requirements. The results of labor force projections are summarized below and in Table 2.

Labor Force Projections

Agricultural production estimates indicate an increase of approximately 180 percent by the year 2020. Eleven percent of the labor force, numbering 50,600 workers, was engaged in agriculture in 1960. Labor force needs commensurate with production levels anticipated by 2020 indicate that 54,200 agricultural workers will be required by that date.

Mining (including petroleum extraction) is important in the economy of the area. Per capita production of minerals is double that of the Nation. In 1960, employment in mining amounted to 18,300 workers or 4 percent of the total area labor force. By 2020, 3 percent of the labor force or 28,900 workers are expected to be engaged in mining.

Forestry and forest products are expected to become more important in the study area. In recent years, less than one-half of the net annual growth in commercial forests in the eastern part of the study area has been harvested. Better management of forests could increase production requiring doubling employment from 5,200 workers in 1960 to 10,400 in 2020.

Manufacturing and processing industries are expected to form an important part of the economic activity in the area. This employment has been increasing since 1940. In 1960, 11 percent of the labor force, 49,800 workers, was employed in manufacturing; by 2020, 20 percent, 225,900 workers, will be so employed.

Service industries such as insurance, finance, sales, personal services, and transportation of goods will continue to employ about 68 percent of the total labor force through the year 2020. In 1960 there were 303,600, and in 2020 it is expected that there will be 762,400 workers in these industries.

Population Projections

The metropolitan population of the study area has been growing at a more rapid rate than the average of metropolitan centers in the Nation. The economic potential of the study area indicates a continuation of this rapid increase. The population of the Oklahoma City Standard Metropolitan Statistical Area is expected to increase from its 1960 level of 511,833 to 1,760,000 in 2020.

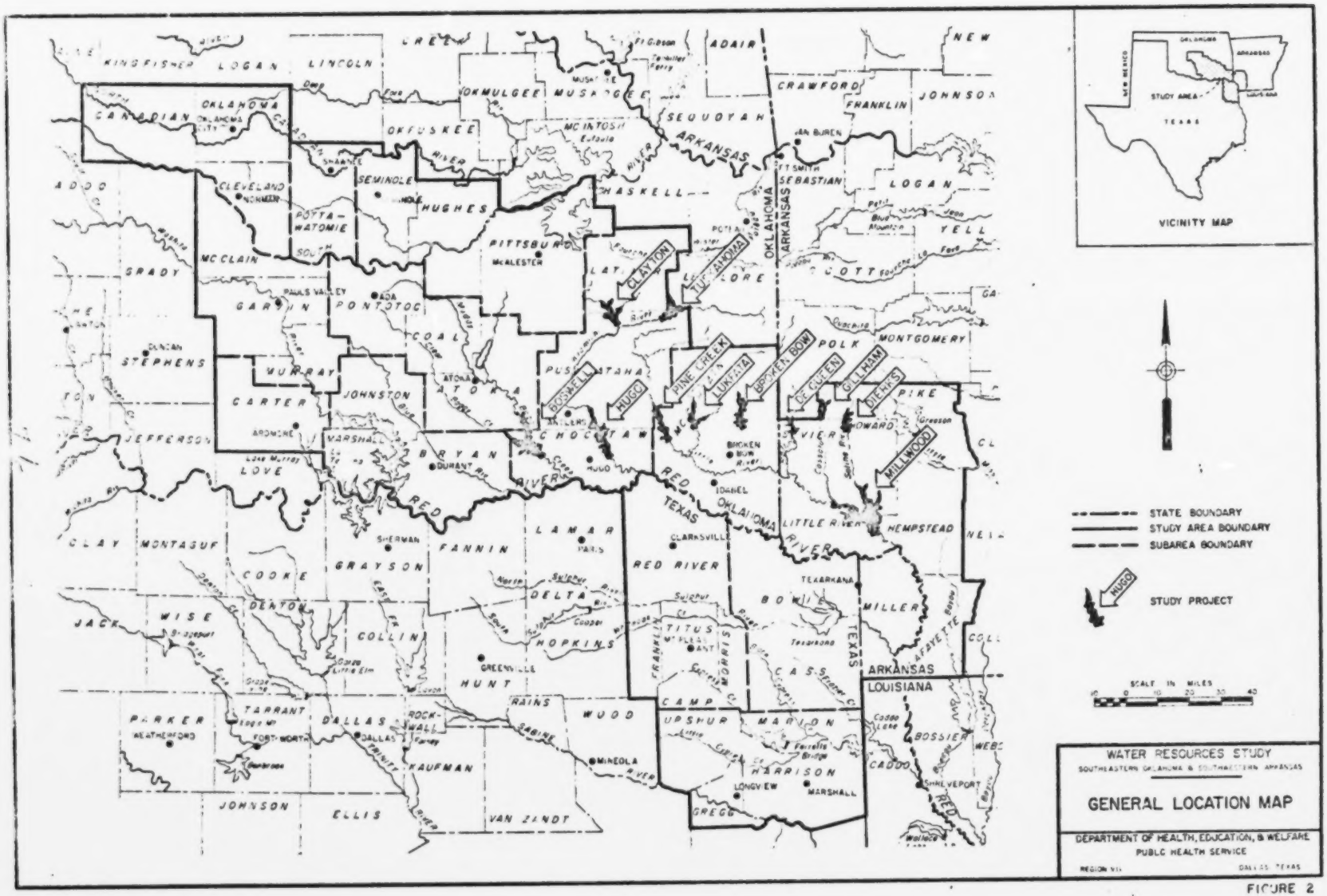

VICINITY MAP
STUDY AREA
TEXAS
OKLAHOMA
ARKANSAS
LOUISIANA
STATE BOUNDARY
STUDY AREA BOUNDARY
SUBAREA BOUNDARY
STUDY PROJECT
HUGO
SCALE IN MILES
0 10 20 30 40
WATER RESOURCES STUDY
SOUTHEASTERN OKLAHOMA & SOUTHWESTERN ARKANSAS
GENERAL LOCATION MAP
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII
DALLAS, TEXAS
KINGFISHER
LOGAN
LINCOLN
CREEK
OKMULGEE
MUSKOGEE
ADAIR
CRAWFORD
FRANKLIN
JOHNSON
CANADIAN
OKLAHOMA CITY
OKFUSKEE
SEQUOYAH
ARKANSAS RIVER
FT SMITH
SEBASTIAN
LOGAN
CLEVELAND
NORMAN
SEMINOLE
HASKELL
POTTAWATOMIE
HUGHES
PITTSBURG
McALESTER
LATIMER
LEFLORE
OKLAHOMA
ARKANSAS
YELL
GRADY
MC CLAIN
SOUTH CANADIAN
CLAYTON
TUSHKAHOMA
COTT
GARVIN
PAULS VALLEY
ADA
PONTOTOC
COAL
MONTGOMERY
POLK
STEPHENS
DUNCAN
MURRAY
CARTER
JOHNSTON
ATOKA
BOGGY DEPOT
HUGO
PINE CREEK
LUKFATA
BROKEN BOW
GLOVER
GILLHAM
DIERKS
PIKE
HOWARD
MILLWOOD
JEFFERSON
ARDMORE
MARSHALL
BRYAN
DURANT
CHOCTAW
HUGO
BIKOKEN
BOKA
LOVE
RED RIVER
IDABEL
TEXAS
OKLAHOMA
LITTLE RIVER
HEMPSTEAD
CLAY
MONTAGUE
SHERMAN
FANNIN
LAMAR
PARIS
CLARKSVILLE
RED RIVER
COOKE
GRAYSON
DELTA
TEXARKANA
BOWIE
MILLER
TEXAS
ARKANSAS
LOUISIANA
JACK
WISE
DENTON
COLLIN
HOPKINS
TITUS
MORRIS
FRANKLIN
CASS
GREENVILLE
HUNT
PARKER
WEATHERFORD
TARRANT
FORT WORTH
DALLAS
ROCKWALL
RAINS
WOOD
CAMP
UPSHUR
MARION
HARRISON
LONGVIEW
MARSHALL
GREGG
BOSSIER
CADDO
SHREVEPORT
RED
KAUFMAN
MINEOLA
JOHNSON
ELLIS
VAN ZANDT

FIGURE 2

A breakdown of population projections for the study area by states is presented in Table 3. Trends for the entire study area are illustrated in Figure 3.

Table 2

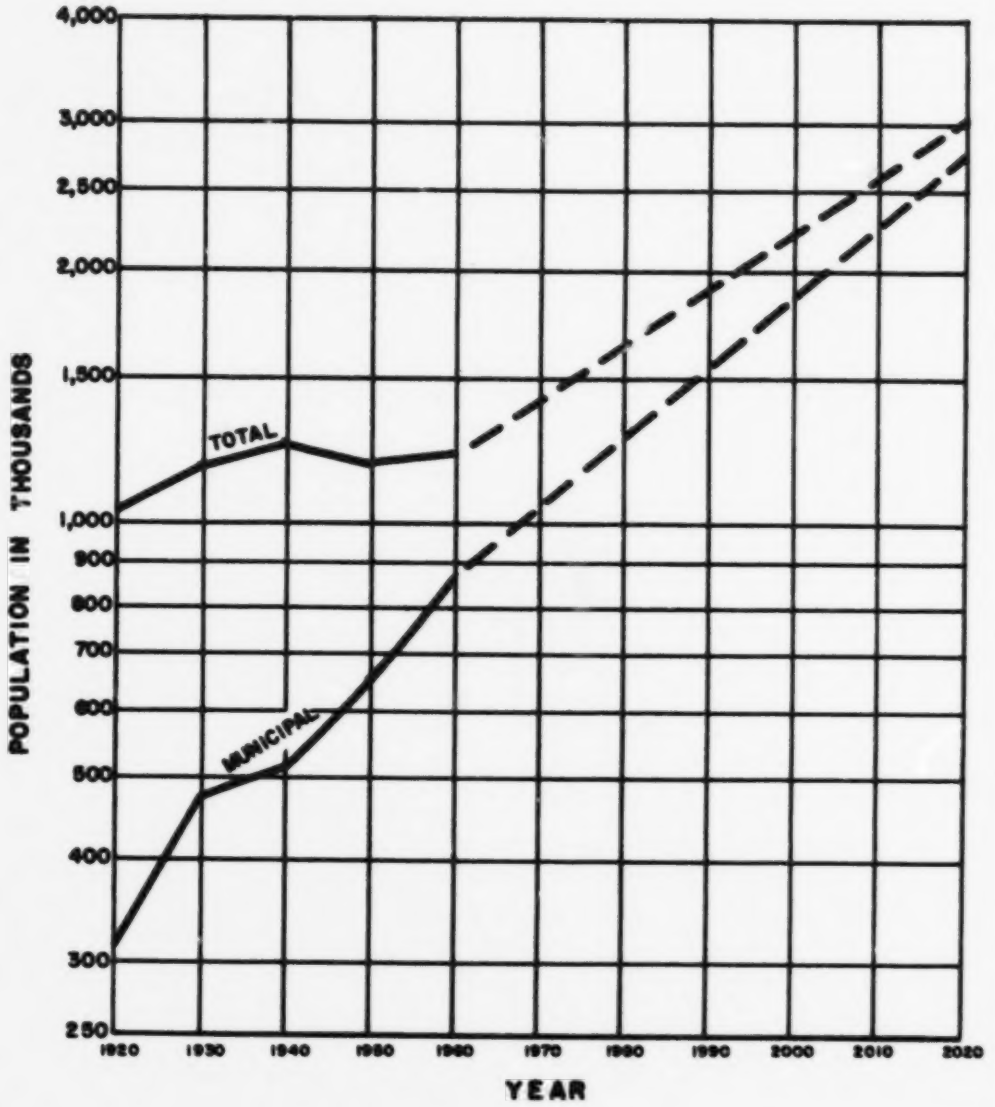
Study Area Employment
Present and Projected

Industry	1960 Labor Force Number	1960 Labor Force Percent	2020 Labor Force Number	2020 Labor Force Percent
Agriculture	50,600	11	54,200	5
Forestry and Fisheries	5,200	1	10,400	1
Mining	18,300	4	28,900	3
Manufacturing	49,800	11	225,900	20
Service Industries	303,600	68	762,400	68
Unemployed	22,500	--	-------	--
Labor Force	450,000	--	1,128,500	--

Table 3

Study Area Population Base and Projections

	1960 Total	1960 Municipal	2020 Total	2020 Municipal
Arkansas	100,486	45,270	156,000	124,000
Oklahoma	863,918	665,909	2,333,000	2,182,000
Texas	284,332	164,928	555,000	453,000
TOTAL	1,248,736	876,107	3,044,000	2,759,000



WATER RESOURCES STUDY
SOUTHEASTERN OKLAHOMA & SOUTHWESTERN ARKANSAS

POPULATION TRENDS
STUDY AREA

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 3

MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS

Municipal

Municipal water needs include residential, public, commercial, and those industrial needs which are served by organized municipal water systems and are reflected in a per capita use figure. Included are distribution system losses, water used for backwashing filters, and other treatment plant losses and evaporation from receiving reservoirs. Future municipal water needs are determined by multiplying the estimated daily per capita use by the projected municipal population of the study area. Table 4 illustrates how per capita use is expected to vary with the size of the city and/or the population served. Estimated total need for municipal water supplies is summarized on Table 5 along with needs for other purposes.

Table 4

Projected Per Capita Water Needs
For the Year 2020

Category	gpcd
Cities with projected municipal populations of 500,000 or more	200
Cities with projected municipal populations of 50,000 to 500,000 and satellite communities of metropolitan centers	180
Cities with projected municipal populations less than 50,000	150

Industrial

Industrial water requirements are here defined as those significant quantities of water required in the manufacture of goods and the processing of materials which are more appropriately measured in units other than a per capita use. The projections of total industrial water requirements are based upon the water requirements per worker and the number of workers projected for each of the major water-using industries. The industrial water requirements summarized with other projected water requirements on Table 5 have been adjusted to take into account regional differences in industrial practices, to adjust for anticipated recirculation and reuse of water, and to eliminate duplication where the needs might reasonably be supplied and accounted for in the municipal estimates.

Table 5

Projected Water Requirements
Southeastern Oklahoma Study Area
2020
(All quantities in mgd)

Area	Municipal	Industrial	Thermal Electric	Total Municipal and Industrial
Hugo-Antlers	5	42	11	58
Oklahoma City	350	200	106	656
Idabel-Broken Bow	4	56	3	63
Southwestern Arkansas Northeastern Texas	101	351	47	499
Intervening Areas	56	70	14	140
TOTAL	516	719	181	1,416

Power Generation

The water requirements for thermal power generation (primarily cooling water) are projected separately because the quality requirements are less stringent and the use pattern differs from that of municipal and industrial water use. Only those uses which result in consumptive water use by the thermal power industry are reflected in the projected requirements. The projections shown on Table 5 are based on data developed by the Federal Power Commission and the Edison Electric Institute for the Senate Select Committee on National Water Resources as well as on information gathered in the study area concerning recycling practices, expected power plant efficiency, and expected municipal and industrial development in the study area.

WATER REQUIREMENTS FOR WATER QUALITY CONTROL

Under the provisions of the Federal Water Pollution Control Act, Public Law 660 as amended by Public Law 87-88, consideration must be given to the inclusion, in any reservoir being planned by a Federal agency, of storage for regulation of streamflow to control water quality. Storage and release of this water is not to be provided as a substitute for adequate treatment or control of wastes at their sources.

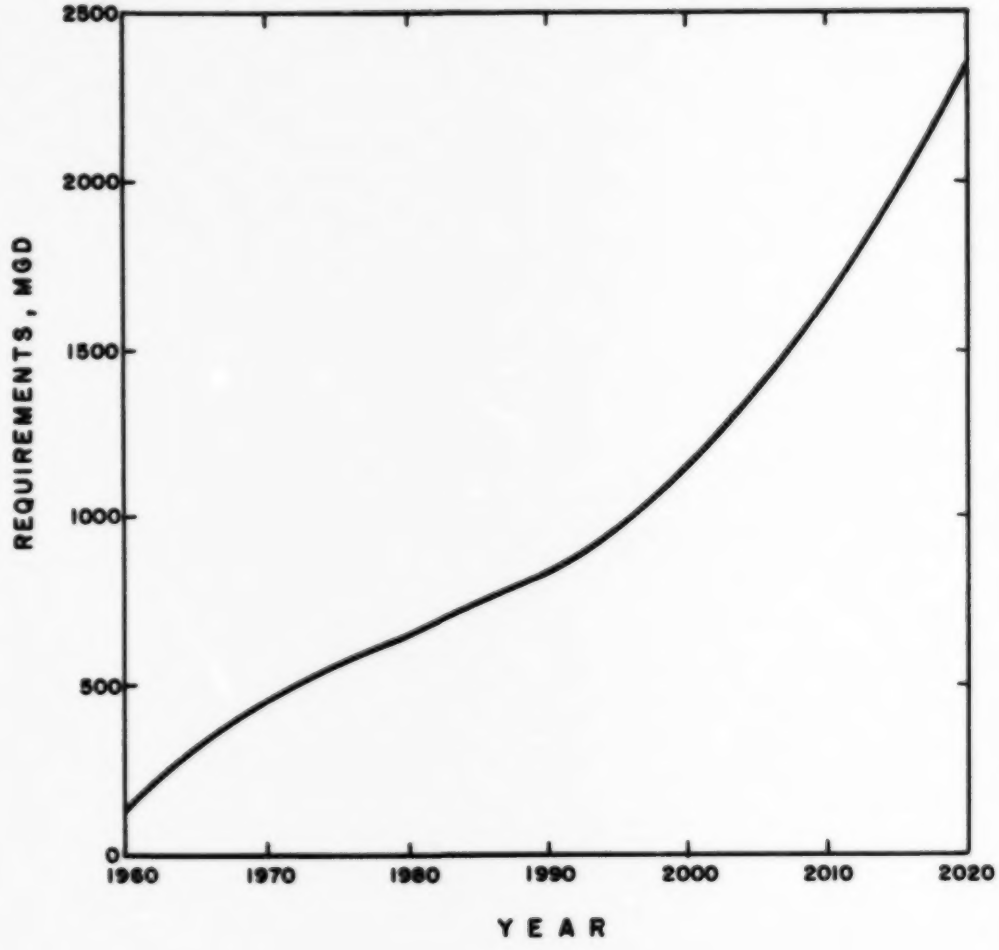
Municipal and Industrial Wastes

Water requirements for water quality control were calculated by estimating the anticipated characteristics and quantities of municipal and industrial wastes and the points at which they would be discharged to the streams of the study area.

The following criteria or conditions were assumed in estimating water quality control requirements: (1) that removal of 90 percent of the organic substances exerting a biochemical oxygen demand (B.O.D.) and that removal of 15 percent of the total dissolved solids will be achieved by treatment, (2) that streamflow records required no adjustment for seepage or evaporation, (3) that treated wastes were mixed uniformly in the receiving waters, and (4) that the dissolved oxygen content would be maintained above 4 ppm, that the dissolved solids would be 500 ppm or less, and that color would not exceed 75 units in the receiving water.

Results of analyses to determine the amount of water required for streamflow regulation and quality control are summarized in Table 6.

The anticipated relationship between time and total need for municipal, industrial, and quality control water (exclusive of the needs for chloride control in the Red River) is shown on Figure 4. Making allowances for existing supplies and reuse of waste water, the entire yield of the 11 reservoirs could be used for these purposes by approximately the year 2020.



* EXCLUSIVE OF NEEDS FOR CHLORIDE CONTROL IN THE RED RIVER.

WATER RESOURCES STUDY

SOUTHEASTERN OKLAHOMA & SOUTHWESTERN ARKANSAS

PROJECTED MUNICIPAL, INDUSTRIAL, AND WATER QUALITY CONTROL REQUIREMENTS*

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 4

Table 6

Water Required for Quality Control
Municipal and Industrial Wastes

Area	mgd
Hugo-Antlers	90
Oklahoma City	540
Idabel-Broken Bow	110
Southwestern Arkansas-Northeastern Texas	210
Intervening Areas	0
TOTAL	950

Chloride Pollution in the Red River

The Red River is heavily polluted with salt from natural seeps in its western drainage area. To this natural pollution is added a substantial salt load from oil field operations. Essentially all of the salt enters above Lake Texoma, located at the southwestern corner of the study area.

Lake Texoma does much to even out chloride concentration. Half of the time discharges from this impoundment exceed 280 ppm, and a range of approximately 200 to 490 ppm has been observed in the course of a year. Boggy Creek and the Kiamichi River contain low chloride water which enters the Red River not too far below Lake Texoma. This makes them attractive sources of water for quality control.

By use of water from storage on Boggy Creek and the Kiamichi River, the Red River below Texoma can be maintained at a chloride concentration of 200 ppm or less most of the time. Need for use of these high quality waters to control chloride concentration in Red River would be reduced as natural and oilfield brine pollution is brought under control.

2060 Water Requirements

The Corps of Engineers requested an estimate of water requirements extended for 100 years (to 2060). Anticipated total study area requirements for municipal and industrial water supply and water quality control purposes are 4,470 mgd, based on a projected total study area population of 5,594,000 in the year 2060. Expectations are that 2,400 mgd will be required to serve the needs of metropolitan areas and 2,070 mgd will be needed to satisfy requirements in the nonmetropolitan areas.

HYPOTHETICAL ARRANGEMENT FOR SUPPLYING NEEDS

Needs for water that can be supplied from the 11 reservoirs can be considered in two general categories. These are: (1) storage for flow regulation for chloride control in the Red River below Lake Texoma, and (2) storage for water supply for projected population growth and industrial development in the study area with attendant need for flow regulation to control quality in waters into which adequately treated municipal and industrial wastes are released.

Red River

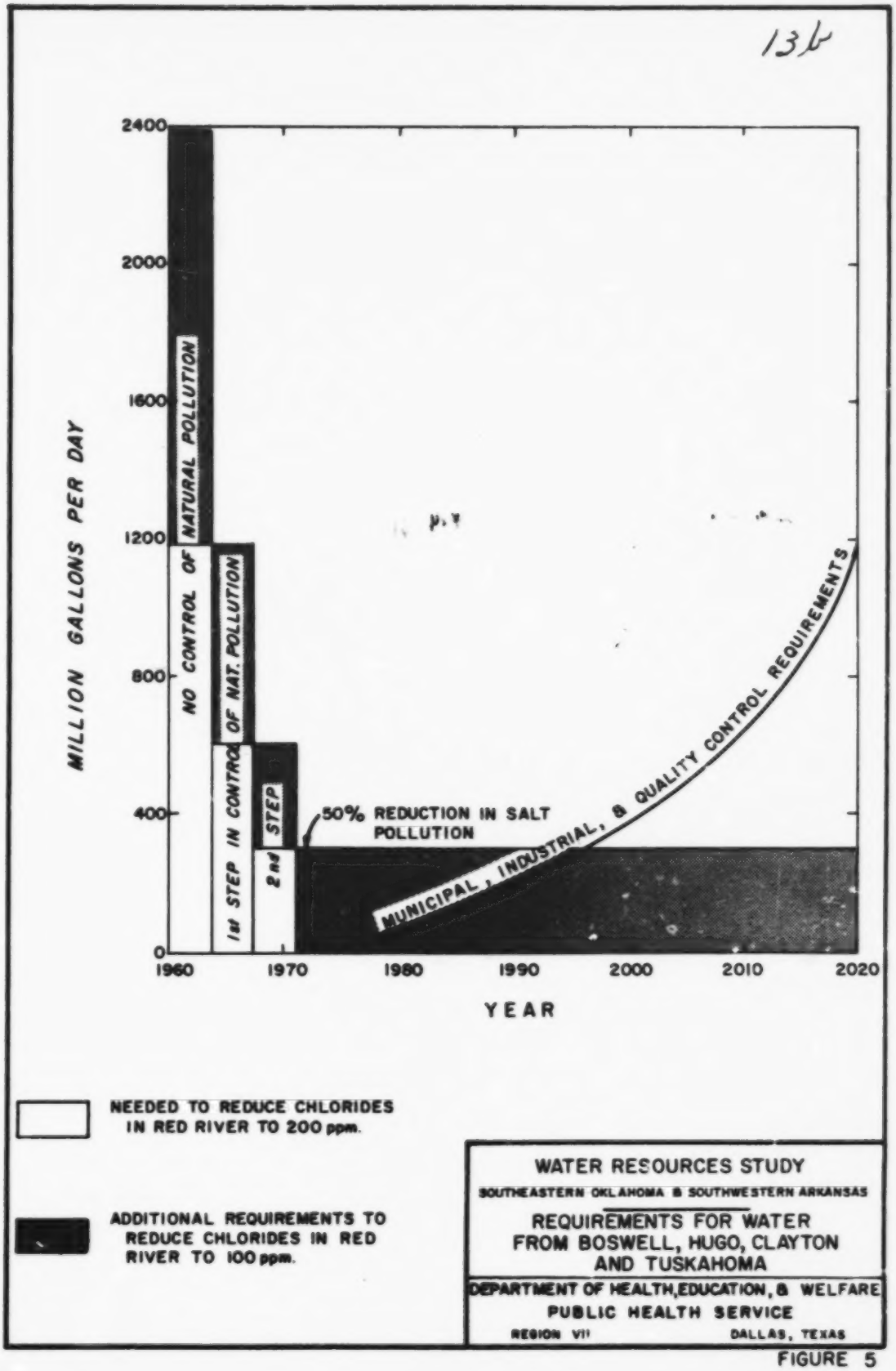
Figure 5 illustrates the requirements for water which could be provided from storage in the proposed Boswell, Hugo, Clayton, and Tuskahoma Reservoirs. At first, the full yield (1,175 mgd) will be needed to maintain chlorides at or below a monthly average of 200 ppm most of the time. Effective measures to control salt pollution above Lake Texoma would permit the use of water stored in these reservoirs to bring the chloride concentration down to a more desirable level.

With success of the joint Public Health Service - Corps of Engineers effort to control natural salt pollution, it is expected that by the year 1975 chlorides could be brought to the 100 ppm level in the Red River downstream from Lake Texoma. (While 100 ppm chlorides is significantly below the Public Health Service maximum desirable limit of 250 ppm, the lower more desirable concentration will provide for future assimilation of chlorides without exceeding the recommended maximum concentration of 250 ppm chlorides.) Thereafter, chlorides could be maintained at or below 100 ppm with less water than these reservoirs are capable of providing.

Storage in the reservoirs could serve both the needs of chloride control in the Red River and the requirements of other portions of the study area until some time after the year 2010. The full yield of the combined reservoirs will be needed for municipal and industrial water supply together with quality control purposes by the year 2020.

Study Area

The projections of population growth and industrial expansion indicate a need of 1,416 mgd for municipal and industrial supplies by the year 2020. Treated municipal and industrial wastes discharged to the rivers of the area will generate a need for an additional 950 mgd for streamflow regulation for quality control in addition to the need for chloride control in the Red River.



WATER RESOURCES STUDY

SOUTHEASTERN OKLAHOMA & SOUTHWESTERN ARKANSAS

REQUIREMENTS FOR WATER FROM BOSWELL, HUGO, CLAYTON AND TUSKAHOMA

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 5

Table 7 shows a hypothetical arrangement for meeting the total projected need (exclusive of chloride control) of 2,366 mgd for the year 2020. In this scheme, it is anticipated that 663 mgd can be supplied from existing sources, including low quality water which would be used wherever it is available for cooling purposes. A net total of 1,703 mgd is thus indicated to be needed from the 11 reservoirs, whose combined yield is 1,906 mgd.

From the foregoing analysis, it is evident that additional water resource development or other methods of water conservation will be required to support continued economic expansion at a comparable rate after the year 2020.

Table 7

Water Requirement Projections and Proposed Source of Supply for Year 2020

Area and Type of Requirement	Quantity Required (mgd)	Source of Water Supply	Quantity (mgd)
Hugo-Antlers			
Municipal	5	Existing Sources	3
Industrial	53	Hugo Reservoir	145
Quality Control	90		
Total	148		148
Oklahoma City		Existing Sources	140
Municipal	350	Boggy-Kiamichi System	1,030
Industrial	306	Low Quality Cooling Water	
Quality Control	540	(165 mgd available)	150
Total	1,196		1,320
Idabel-Broken Bow		Broken Bow Reservoir	175
Municipal	4		
Industrial	59		
Quality Control	110		
Total	173		175
Southwestern Arkansas-Northeastern Texas		Existing Sources	66
Municipal	101	Ferrells Bridge Reservoir	164
Industrial	398	Millwood Reservoir	265
Quality Control	210	Little River System (Pine Creek, Gillham, DeQueen, Dierks, and Lukfata Reservoirs)	291
Total	709		786
Intervening Areas			
Municipal	56	Ground Water & Numerous	
Industrial	84	Local Impoundments	140
Total	140		140

VALUE OF STORAGE FOR MUNICIPAL, INDUSTRIAL, AND WATER QUALITY CONTROL PURPOSES

Method of Evaluation

The report of the Sub-Committee on Evaluation Standards of the Federal Inter-Agency Committee on Water Resources recommends the following method of evaluating storage in Federal reservoirs for municipal and industrial water supply:

> "From an over-all public viewpoint, a municipal and industrial water supply development will be economically justified if it provides water to meet expected needs at a cost not greater than the cost of the alternative source that would likely be utilized in the absence of the project."

This principle has been adopted in this study and was also used in evaluating storage for water quality control, since there is no present widely accepted alternative to regulated streamflow for maintaining stream quality at suitable levels.

Alternative Plans Considered

Following investigation of various possibilities, single-purpose reservoirs at the sites of the multipurpose projects were adopted as the most reasonable alternatives. A single-purpose impoundment having a yield equal to the water supply portion of the multipurpose project was assumed in each case to meet the projected requirements from the project for municipal, industrial, and stream quality control purposes.

Cost figures for construction, operation, and maintenance of single-purpose reservoirs at project sites were furnished by the Corps of Engineers. An economically useful life of 50 years and a non-Federal interest rate of 4 percent were assumed for converting capital costs to equivalent annual costs. These costs were then discounted from time of first use to 1970 for comparison.

On this basis, the summary of annual benefits attributable to the projects is shown in Table 8.

Control of water quality by streamflow regulation utilizing storage in the proposed projects will make water of suitable quality available throughout the basins where this control is provided. Benefits from storage for water quality control in these projects, therefore, can be considered widespread.

Table 8

Summary of Benefits

Reservoir	Purpose	% of Yield	Average Annual Benefit at Time of First Need ($1,000's)	Projected First Need	Average Annual Benefit* ($1,000's)
Boswell	Municipal and Industrial Water Supply	47	466	1970	466
	Water Quality Control	53	526		526
Hugo	Municipal and Industrial Water Supply	57	320	1970	320
	Water Quality Control	43	242		242
Clayton	Municipal and Industrial Water Supply	47	184	1970	184
	Water Quality Control	53	208		208
Tuskahoma	Municipal and Industrial Water Supply	47	218	1970	218
	Water Quality Control	53	246		246
Pine Creek	Municipal and Industrial Water Supply	70	316	1995	119
	Water Quality Control	30	135		50
Lukfata	Municipal and Industrial Water Supply	70	158	1995	59
	Water Quality Control	30	68		26
Gillham	Municipal and Industrial Water Supply	70	244	1995	91
	Water Quality Control	30	105		40
DeQueen	Municipal and Industrial Water Supply	70	127	1995	49
	Water Quality Control	30	54		21
Dierks	Municipal and Industrial Water Supply	70	78	1995	29.5
	Water Quality Control	30	33		12

* Discounted to 1970 from time of first need.

Benefits of storage, shown in Table 8, are based upon expected yields from storage to be provided in the proposed reservoirs. Studies of hydroelectric power are being, or will be, undertaken by the Corps of Engineers for these projects; however, these studies are not sufficiently advanced for use at this time. Potential benefits to water quality which could be ascribed to larger discharges resulting from power production (assuming proper regulation of releases) at each project site should be evaluated when sufficient detail is available.